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SEISMIC BEHAVIOR OF DIFFERENT BRACING SYSTEMS IN HIGH RISE RCC BUILDINGS

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ABSTRACT

The high-rise buildings that are made of RCC frame, the greater importance is given to make structure safe against lateral load. These loads are produced due to wind, earthquakes etc. To resist lateral load acting on building different types of steel or RCC bracing systems are provided. The use of RCC bracing has potential advantage than other bracing like higher stiffness and stability. This study aimed the comparison of different RCC bracing system under seismic behavior in high rise buildings. Also three structural configurations used in this paper are Moment Resisting Frames (MRFs), X-Braced Frames (XBFs), V-Braced Frames (VBFs) for 11 storey (G+10) building. The bracing systems provided on periphery of the column. The frame models are analyzed as per IS: 1893-2000 using STADD.ProV8i and ETABs software's. The parameters which are considered in this paper for comparing seismic effect of buildings are base shear and storey displacement. The results showed that X-braced frames are more efficient and safe at time of earthquake when compared with moment resisting frames and V-braced frames.

Key words – Base shear, RCC bracing, Seismic behavior, Seismic analysis, Storey displacements

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1. INTRODUCTION

1.1. General

Generally the purpose of high rise buildings is to transfer the primary gravity load safely. The common gravity loads are dead load, live load. Also the structure should withstand the lateral loads caused by earthquake, blasting, and wind depending on terrain category. The lateral loads reduce stability of structure by producing sway moment and induce high stresses. So in such cases stiffness is more important than strength to resist lateral loads.

There are various ways of providing bracings to improve seismic performance of buildings. The different bracing configurations typically used are: Diagonal bracing, Cross bracing(X), Chevron bracing, and V-bracing. Each bracing configurations has its own merits and demerits as compared to other. (Figure. 1)

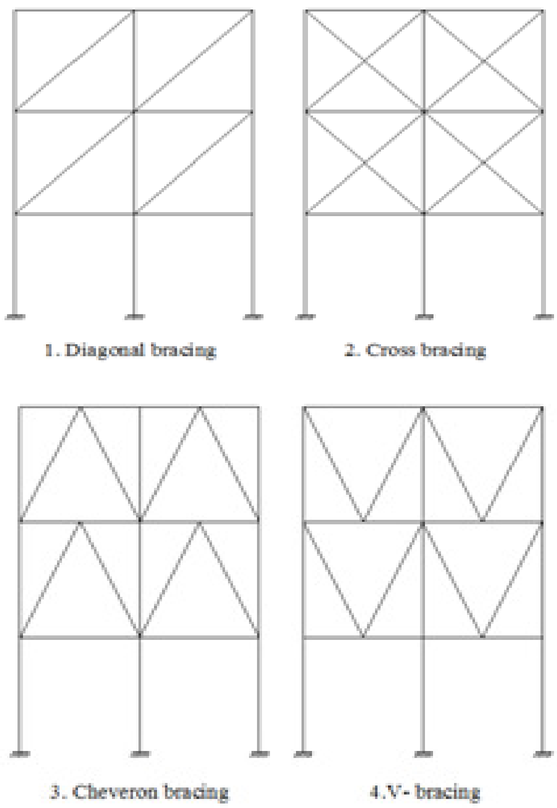


Figure 1 Different Configurations of Bracings

1.2. Literature Review

Dhanaraj and Keshav (1) studied seismic performance of different bracing systems in multi storey steel buildings. The parameters considered are storey displacement; inter storey drift ratio, base shear and performance point when compared with moment resisting frames. They concluded that the use of Chevron Braced Frame (CBF), Zipper Braced Frame (ZBF), V braced frame (VBF) enhances structural performance in 2D steel building.

Kevadhkar and Kodag (2) studied RCC building with three models as MRF, different shear wall systems and different bracing systems and they found that X-braced system increases the stiffness and reduces the inter storey drift, lateral displacement and performance point than shear wall system.

Kulkarni and Kore (3) analyzed numerically in 12 storey building with 5 bay structures that arrangement of V-Braced system in particular bay, level and their combination reduces the lateral displacement in comparison with moment resisting frame.

Numan and Islam (4) concluded from their study the maximum displacement of the structure decreases after application of X braced system as compared to different types of steel system. Also by application of bracing system the bending moment and shear forces reduces in columns.

1.3. Objective of Study

The main objective of this paper is to analyse the RCC high rise building subjected to seismic load with following parameters:

Base shear – To calculate the total design lateral force at the structure and to analyse the effect of different configuration of bracing on structure.

.Storey displacement – To evaluate the lateral displacement that occurs in each storey of high rise buildings.

Also these parameters are evaluated using different types of bracing and to choose appropriate bracing configuration to resist seismic load efficiently. Also to check the seismic response on different software's.

2. MODELING AND ANALYSIS

The RCC building consists of 11 storey (G+10) having a typical floor plan with 4 bays 4m each along both longitudinal and transverse directions as shown in Figure.2. The storey height of 3.2m is considered for all the floors.

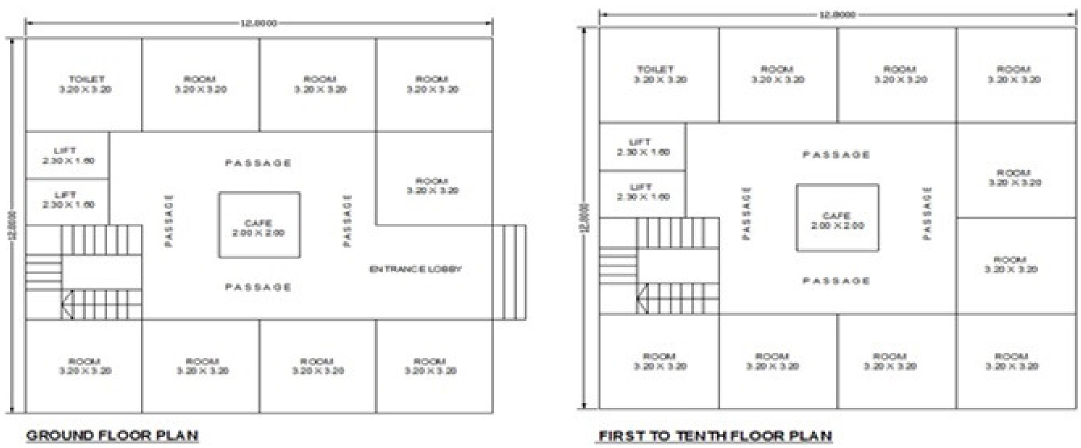


Figure 2 Building Plan

2.1. Modeling

The STADD Pro and ETABs software's are used for modeling and to carry out the analysis. The lateral loads subjected to the buildings are considered as per Indian standard codes. The different types of building frames are considered for analysis as;

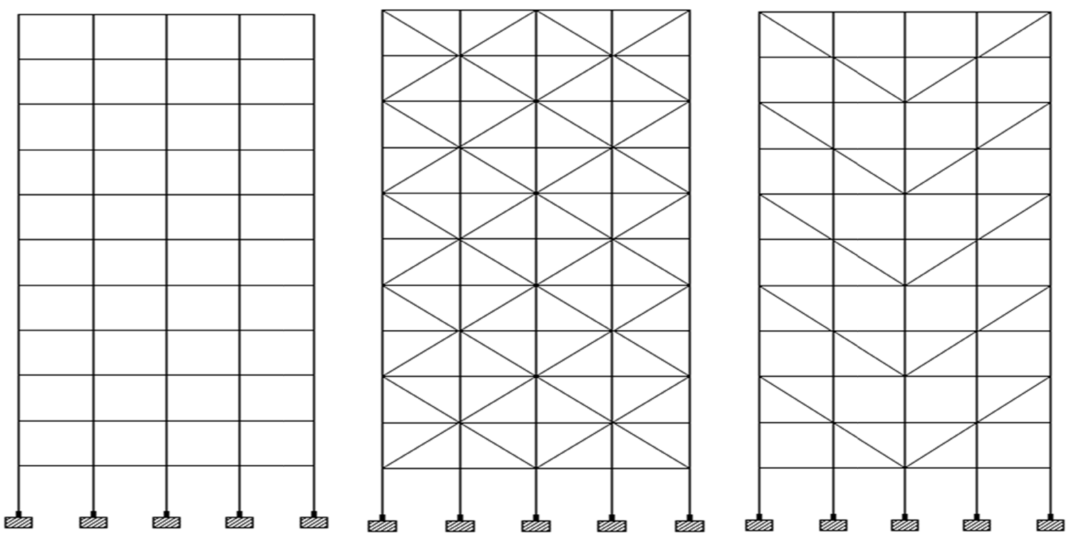
1. Moment Resisting Frame (MRF)
2. RCC building with V-bracing system (VBF)
3. RCC building with X- bracing system (XBF)

Table 1 Structure parameter

Structure	SMRF
Number of storey	G+10
Type of building used	Commercial
Storey Height	3.20 meters
Grade of concrete	M_{30}
Grade of steel	Fe 415
Young's modulus of concrete	2.74 X 10^7 kN/m^2
Young's modulus of steel	2.00 X 10^8 kN/m^2
Density of RCC	25 kN/m^2
Thickness of slab	0.150m
Beam size	0.30m X 0.45m
Column size	0.30m X 0.45m
Bracing size	0.30m X 0.30m
Dead load intensity	12 kN/m^2 (on floors)
	10 kN/m^2 (on roofs)
Live load intensity	5 kN/m^2 (on floors)
	2 kN/m^2 (on roofs)
Seismic zone (Z)	II
Importance factor (I)	1
Response reduction factor	5
Soil type	2 (medium)

All the above mentioned building frames are analyzed as per requirement of IS: 456-2000 and IS: 875-1987. The seismic analysis is carried out on models using two software. The equivalent static load analysis is carried out using STADD ProV8i and the response spectrum analysis is carried out using ETABS. The load combinations considered in seismic analysis are done as per IS: 1893-2002.

2.1.1. Modeling on STADD Pro



a) MRF b) X Bracing c) V Bracing

Figure. 3 Different configurations of buildings (STAAD PRO)

2.1.2. Modeling on ETABS

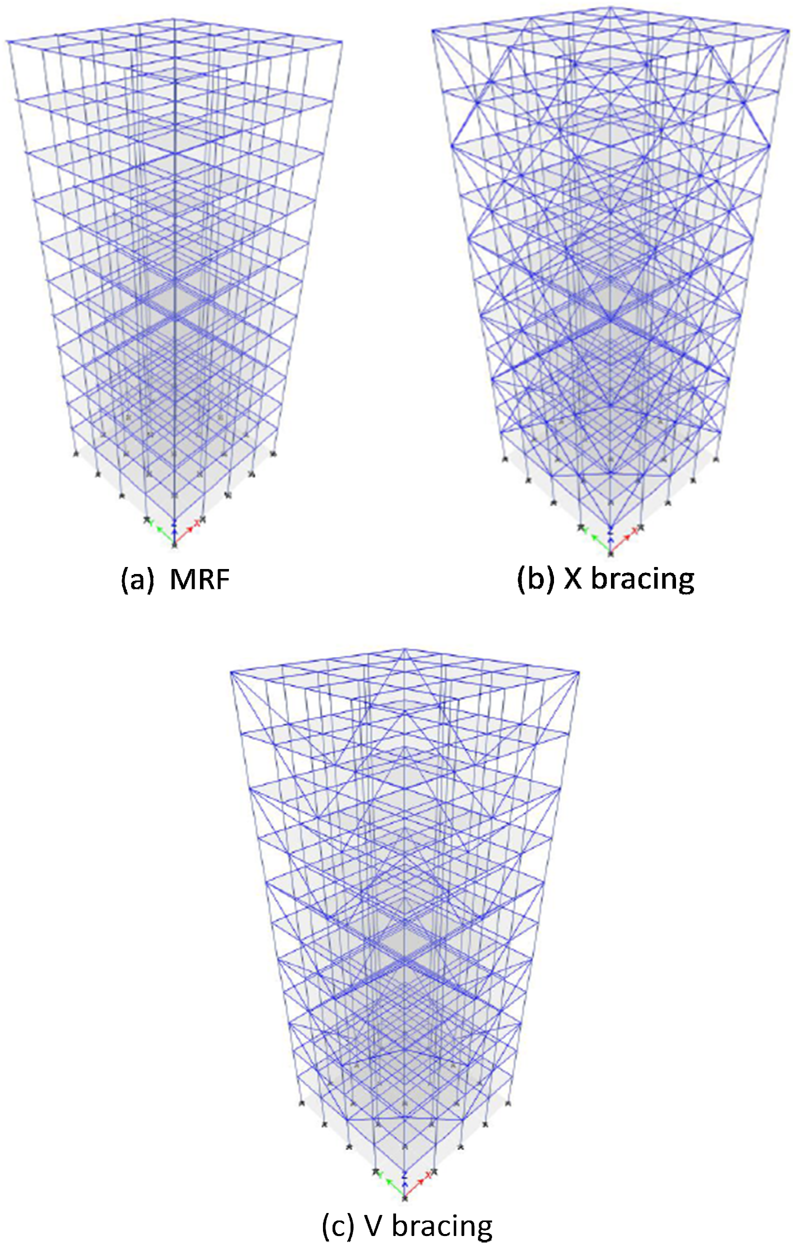


Figure. 4 Different configurations of buildings (ETABS)

3.1. Analysis

The sample calculation for MRF type building as per IS 1893-2002 by static analysis method is given below:

Step 1) Design Parameter:

The seismic parameters required for calculations of base shear are assumed as per table (1).

Step 2) Seismic Weight:

The floor area is = 163.84 m^2

Since the live load is 5 kN/m^2.

As per IS 1893, 50% of total live is consider for evaluating seismic load.

Floor = W_1=W_2 = up to W_{10} = 163.84 X (12+0.5 X 5) = 2375.68 kN

Roof = W_{11}= 163.84 x [10+ (2 X 0.25)] = 1720.32 kN

Total seismic weight of the structure

$\sum W$ =25477.12 kN

Step3) Fundamental Period

$$T = \frac{0.09h}{\sqrt{d}} = \frac{0.09 \text{ X } 35.2}{\sqrt{12.8}} = 0.8854 \text{ sec.}$$

Step4) Seismic coefficient

$$Ah = \frac{Z}{2}\frac{I}{R}\frac{Sa}{g} = \frac{0.10}{2} \text{X } \frac{1}{5} \text{ X } 1.5360 = 0.01536$$

Step 5) Design base shear (V_b)

$V_b = A_h W$ = 0.01536 X 25477.12 = 391.32 kN

Step 6) Lateral load distribution with height

Table 2 Lateral Force level Direction

Storey	Weight W_i (kN)	Height h_i (m)	$\frac{Wihi^2}{1000}$	$\frac{Wihi^2}{\sum Wihi^2}$	Lateral force i^{th} level direction (KN)
11	1720.32	35.2	2131.545	0.185	72.548
10	2375.68	32	2432.696	0.212	82.798
9	2375.68	28.8	1970.480	0.171	67.066
8	2375.68	25.6	1556.925	0.135	52.991
7	2375.68	22.4	1192.021	0.104	40.571
6	2375.68	19.2	875.770	0.076	29.807
5	2375.68	16	608.174	0.053	20.699
4	2375.68	12.8	389.231	0.034	13.248
3	2375.68	9.6	218.942	0.019	7.452
2	2375.68	6.4	97.307	0.008	3.312
1	2375.68	3.2	24.326	0.002	0.828
Total			11497.42	1.000	391.32

4. RESULTS AND DISCUSSIONS

4.1. Base shear

The maximum base shears at the base for without and with different RC braced building are shown in the Figure. (5)

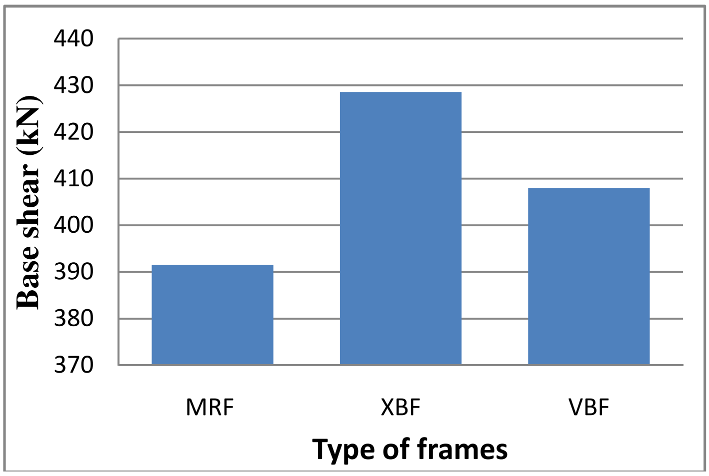


Figure 5 Base Shear

From the above figure it can be observed that the base shear in XBF gives higher value as compared to VBF and moment resisting frame. It is seen that as stiffness of the bracing section increases the base shear in the building also increases in both direction.

4.2. Storey displacement

The graph of storey displacement versus number of storey are plotted along X axis and Y-axis respectively for MRF and with different RC braced building using STAAD Pro as shown in Figure.(6)

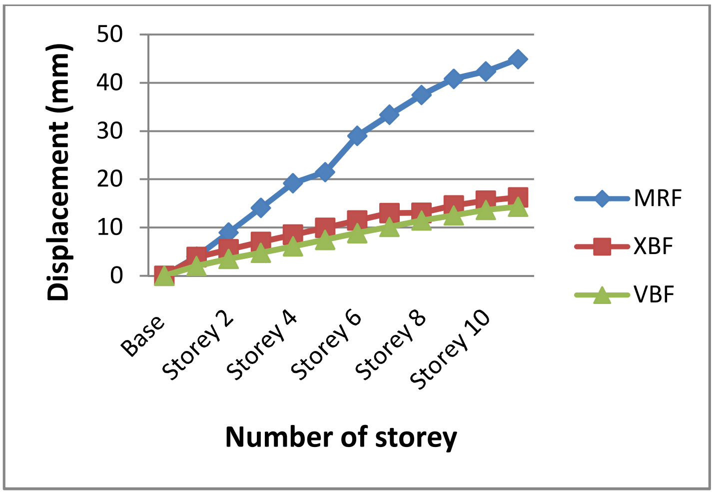


Figure. 6 Storey Displacement (STAAD Pro)

From the above figure it is observed that the storey displacement is reduced to greater extent for the XBF, while displacement is maximum for without bracing stiffness. These patterns are observed due to increased stiffness in XBF as compared to VBF. The top roof displacement for XBF is reduced by 61.60%. And that for VBF is reduced by 58.48% when compared to that of without bracing system.

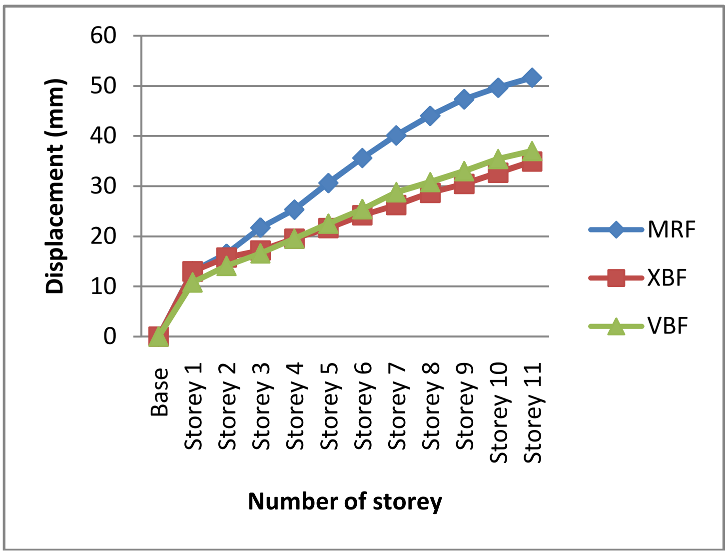


Figure. 7 Storey Displacement (ETABS)

5. CONCLUSION

In this paper the different braced buildings are studied and the seismic parameters in terms of base shear and storey displacement are compared. The following conclusions are summarized based on analysis:

1. In high rise buildings, the parameters like strength and stiffness are more important. So for this purpose bracing system are adopted to enhance both these parameters. MRF buildings showed higher storey displacement that it is weak as compared other braced buildings, so prone to excessive damage in earthquake.
2. The base shear of braced buildings increased as compared to building without bracing which indicates that the stiffness of building increases.
3. The storey displacement of the building is reduced by 55% to 60% by using XBF and VBF.
4. The performance of XBF has more margin of safety when compared to VBF.
5. The RC bracing has one of advantage that it can be used to strengthen the existing structure.

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